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[54] METHOD AND APPARATUS FOR DETECTING INCIPIENT SHORT CIRCUIT CONDITIONS IN ELECTROLYTIC CELLS

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[52] **U.S. Cl.** **250/338,** 250/316, 250/563

[51] **Int. Cl.** **G01t 1/00,** G01n 21/30

[58] **Field of Search** ....250/338, 316, 317, 342, 250/347, 563; 73/15 R

[56] **References Cited**

UNITED STATES PATENTS

3,531,642	9/1970	Barnes et al.	250/338
3,350,702	10/1967	Herman	250/338
3,209,149	9/1965	Tucker	250/316
3,448,209	6/1969	Nyman	250/316

OTHER PUBLICATIONS

"Infra Red Scans For Inner Defects," by Malim Reprint from Iron Age, May 27, 1965.

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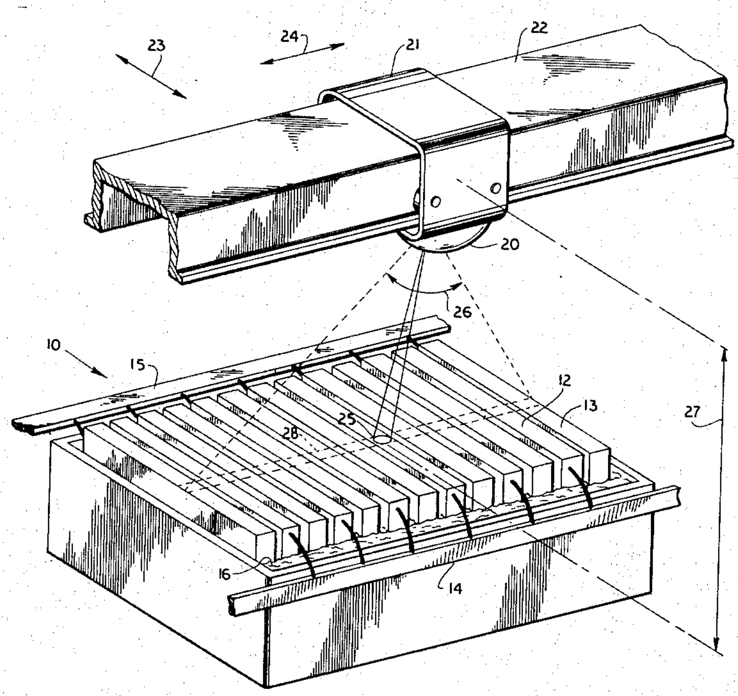
[57] **ABSTRACT**

Method and apparatus for detecting the existence of short circuit conditions between adjacent electrodes positioned in an electrolytic cell. Electrolytic cells of the type characterized by an anode and a cathode, both of which are substantially immersed in a suitable electrolyte, not infrequently develop short circuit conditions caused by physical contact between adjacent electrodes. Incipient short circuit conditions in an electrolytic cell are detected prior to the earliest time of detectability by using prior-art measurements, by scanning the surface of the cell with an infrared sensing apparatus at conditions of scan which permit detection of the thermal abnormality created by the existence of the short circuit condition. The present method and apparatus is useful to scan a large number of electrolytic cells as found in a production facility, so that each of such cells can be rapidly evaluated to determine the possible existence of incipient short circuit conditions.

18 Claims, 4 Drawing Figures



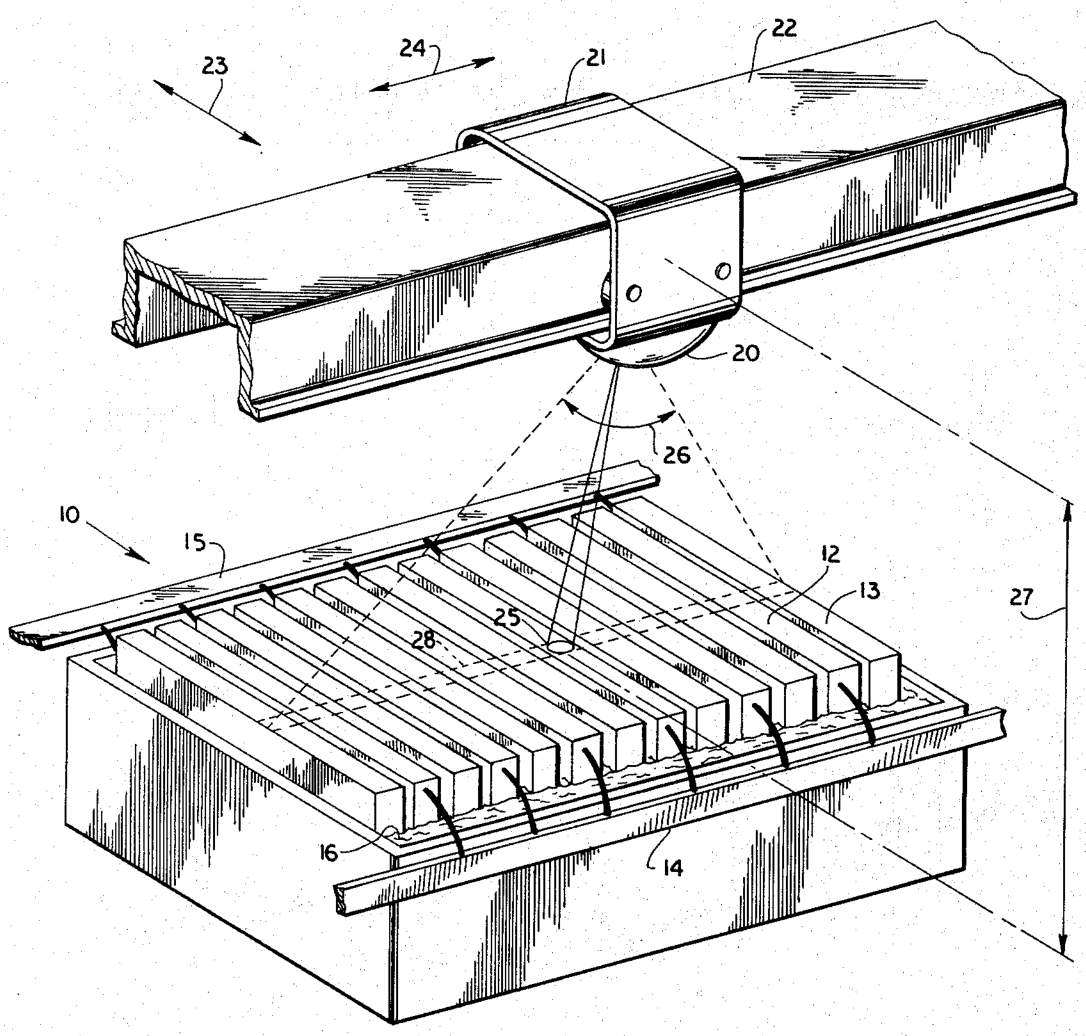

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FIG 1

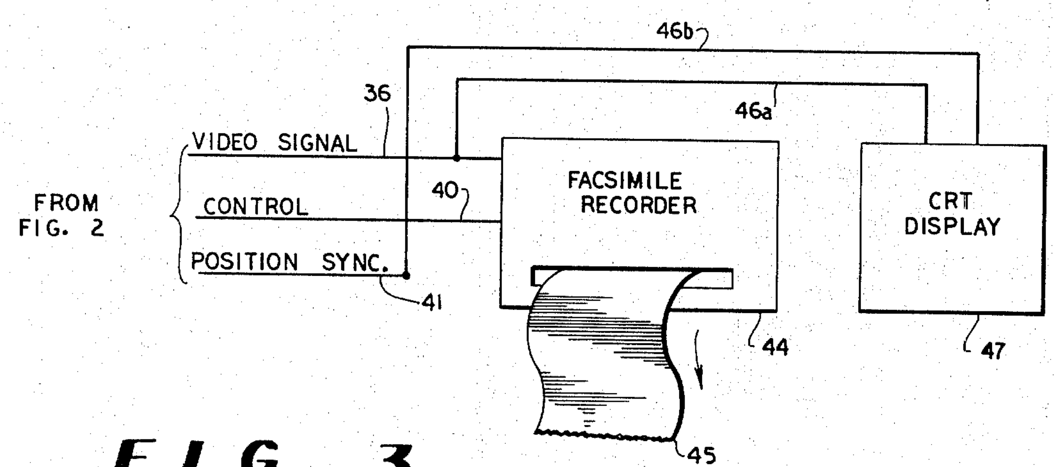
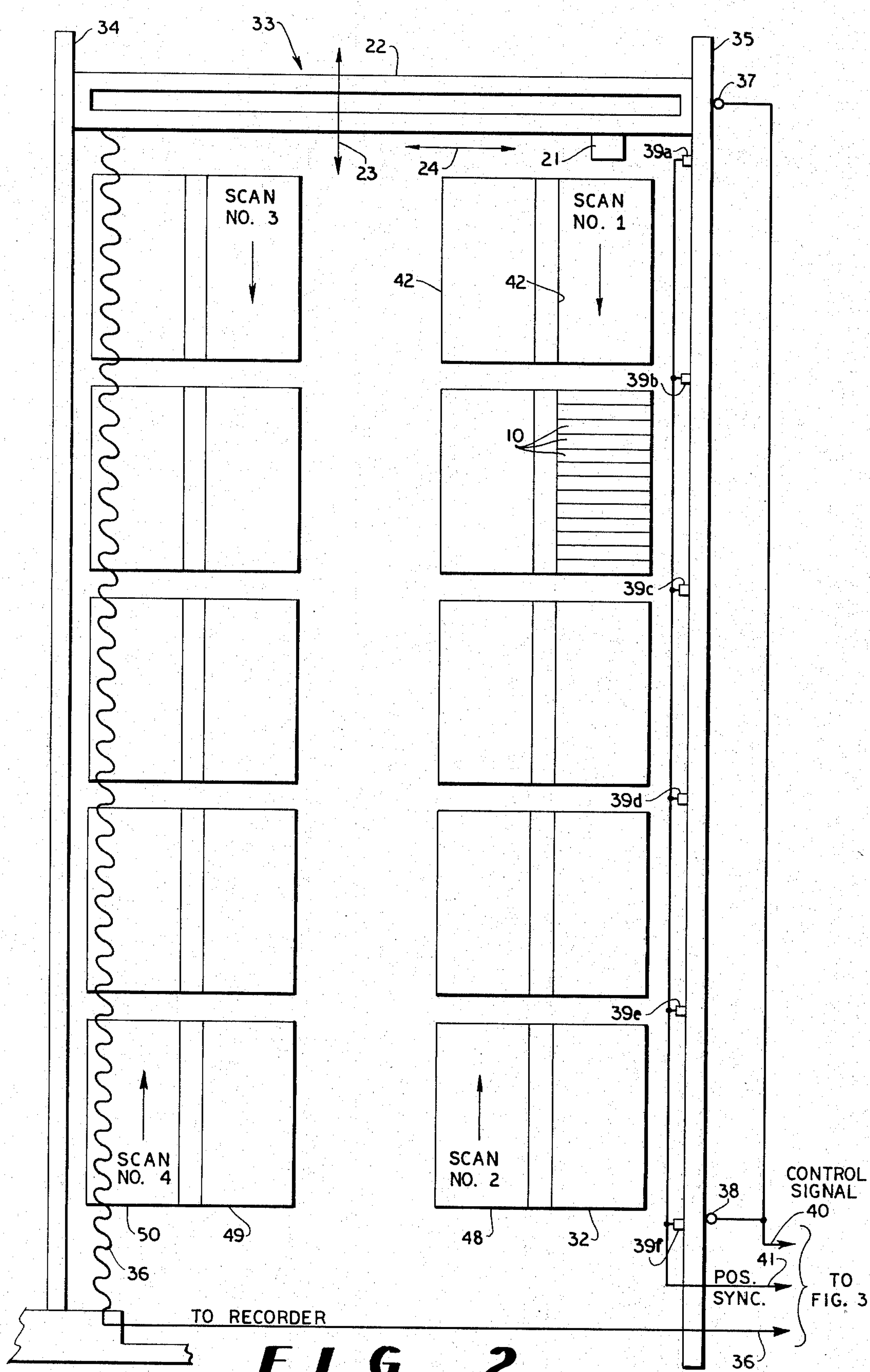

FROM
FIG. 2
VIDEO SIGNAL
CONTROL
POSITION SYNC.
36
40
41
46a
46b
FACSIMILE
RECORDER
CRT
DISPLAY
44
45
47

FIG 3


34
33
22
35
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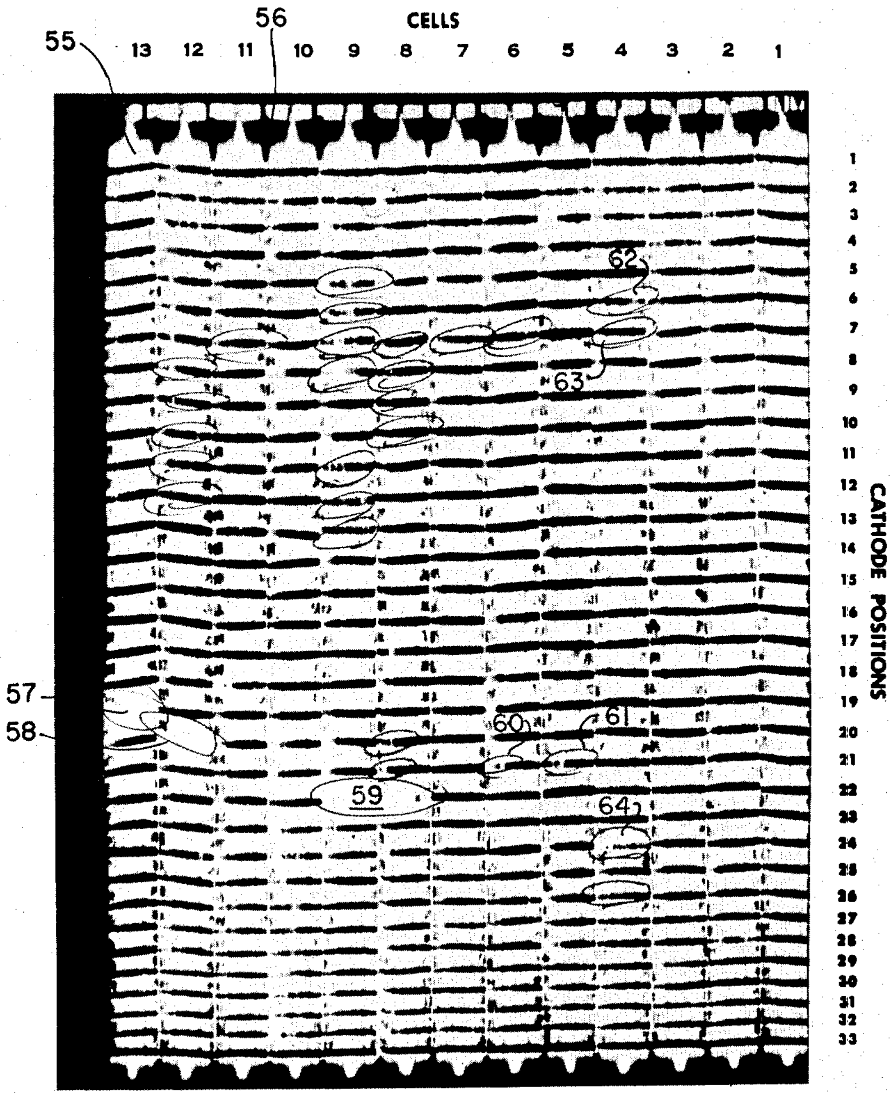
23
24
21
39a
SCAN NO. 3
SCAN NO. 1
42
42
39b
10
39c
39d
39e
SCAN NO. 4
SCAN NO. 2
38
CONTROL SIGNAL
40
50
49
48
32
39f
41
36
POS. SYNC.
TO FIG. 3
TO RECORDER
36

FIG 2


CELLS
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CATHODE POSITIONS
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FIG. 4

METHOD AND APPARATUS FOR DETECTING INCIPIENT SHORT CIRCUIT CONDITIONS IN ELECTROLYTIC CELLS

This invention relates in general to the detection of short circuit conditions and in particular to the detection of incipient short circuit conditions as found in electrolytic cells used in metal refining operations.

The art of electroplating, in addition to being useful for the application of a relatively thin outer metallic coating on a base or substrate metal, is also of known utility in the refining of metals such as copper. In the electrolytic refining of copper, relatively impure copper anodes are prepared by a conventional casting process and are placed in tanks containing a suitable electrolytic solution such as copper sulphate. The tanks are also provided with suitable cathodes, which typically may consist of relatively pure, thin copper "starter sheets." The relatively impure copper anodes and the relatively pure copper cathodes are connected to a suitable source of electrical current, and the copper is plated from the anodes onto the so-called starter sheets, resulting in cathode sheets of relatively pure copper which are removed from the electroplating tanks for subsequent use.

The electrolytic refining of copper or other metals at production quantities generally requires large numbers of electrolytic cells each containing a number of anodes and cathodes, and the proper operation of each cell depends upon the accurate control of the electric current density between the various anodes and cathodes. It is known to those skilled in the art that short circuits can occur between an adjacent anode and cathode, and such short circuits create a preferential path of current flow in the localized area of the short circuit which raises the current density at such location to a level which is greater than the optimum desired current density. Such short circuits can occur from a number of causes, such as inaccurate initial placement of an adjacent anode and cathode, buckling of the relatively thin cathode starter sheet, or the growth of copper nodules growing from a cathode to touch an adjacent anode during the process of electrolytic refining. Whatever the cause of the short-circuit condition, the metallic cathode which is produced as a result of a short circuit fails to have the desired metallurgical properties, with the result that such unacceptable cathodes must be remelted into relatively impure copper anodes and again subjected to the electrolytic refining process. This means that the electricity initially used in the electrolytic preparation of the defective cathode, as well as the electricity or other fuel used in remelting such cathode, has been wasted along with the attendant waste in time and other expense resulting from production of a defective cathode.

Prior art efforts to detect the presence of short-circuit conditions in electrolytic refining cells have generally involved the use of a portable gauss meter and/or voltmeter measurement of individual cell power conditions. The voltmeter is used in the conventional manner to measure the voltage across each individual electrolytic cell, with an abnormally high or low voltage reading being indicative of either an open-circuit or short-circuit cell condition, respectively. While an open-circuit cell condition, which can be caused by factors such as ineffective contact between a cell electrode and a power supply bus, does not waste electrical power, it will be appreciated that an open-circuit cell is nonproductive of refined metal and represents a defective situation requiring detection and correction. The gauss meter, which those skilled in the art will recognize as an instrument for measuring the field surrounding a conductive member through which electrical current is flowing, is similarly used in prior-art inspection of electrolytic refining tanks to measure the current flowing through the anode and cathode plates. Prior-art gauss meter measuring techniques require the services of an inspector who manually passes the gauss meter over the anode and cathode plates of each individual tank in an attempt to detect the existence of an abnormal current condition associated with one or more plates.

It is apparent from the foregoing description of prior art technique that several individual manual measurements are required to be made at each and every cell of an electrolytic refining operation each day, if the proper operating condition of the cells is to be evaluated and maintained. The resulting requirements for inspection manpower are very large, especially since commercial production capabilities of electrolytic refining typically call for a large number of individual cells and cell electrodes. For example, an installation for the electrolytic refining of copper may have a plurality of bay work areas, with each bay housing 10 sections of electrolytic cells. Each of these cell sections includes 26 separate cells, and each cell in turn contains 33 cathodes and corresponding anodes, and so it can be seen that each bay of this typical installation includes a total of 17,160 electrodes. It is apparent that the inspection of each electrode with the prior art techniques of voltmeter and gauss meter, requiring an inspector to walk along sections of electrolytic cells containing heated electrolyte to make individual voltage and current field measurements of each electrode associated with each cell, is both hazardous and time-consuming.

Furthermore, short-circuit detection techniques of the prior art require a high level of operator expertise to evaluate the meter readings of a voltmeter and/or a gauss meter to determine whether the particular meter readings actually indicate a short-circuit condition. Added to all of the foregoing difficulties associated with prior-art techniques is the additional problem that such inspection techniques are generally capable of detecting only a short circuit which has been in existence for at least 6 to 12 hours, at the earliest, depending upon the current density, thus requiring the cathode to be reworked as described above with attendant loss of electrical energy and work in process. Although substantial effort has been spent in attempts to develop a system which will detect the presence of an electrolytic cell short circuit condition at an earlier time in the operation of the cell, the conventional gauss meter has continued to be considered the instrument which operates with the degree of reliability and repeatability demanded of production metal refining operation.

The term "incipient short circuit," as the term is used herein, means a short circuit condition which exists in an electrolytic cell but which has not yet developed to a magnitude where the short circuit condition can be detected with conventional gauss meter measurement.

Accordingly, it is an object of the present invention to provide an improved method and apparatus for inspecting electrolytic cells.

It is another object of the present invention to provide a method and apparatus for detecting the presence of an electroplating cell condition which indicates the existence of a short-circuit condition in the cell.

It is still another object of the present invention to provide a method and apparatus for detecting the existence of incipient short-circuit conditions in electroplating cells.

It is a further object of the present invention to provide method and apparatus for detecting the existence of incipient short-circuit conditions in one or more of a plurality of grouped-together electroplating cells without requiring manual inspection of each and every cell.

Other objects and attendant advantages of the present invention will become more readily apparent from the following description of a working embodiment thereof, including the annexed drawing wherein:

FIG. **1** is a schematic isometric view of a cell scanning operation according to an embodiment of the present invention;

FIG. **2** is a plan view of a metal refining tankhouse installation equipped for cell scanning according to the disclosed embodiment of the present invention;

FIG. **3** is a schematic view of the readout portion of the disclosed embodiment; and

FIG. **4** is a photographic reproduction of an actual facsimile recorder printout produced by the disclosed embodiment of the present invention and showing various anomolous cell conditions, as described in detail below.

Stated in general terms, incipient short-circuit conditions are detected according to the present invention by scanning an electroplating cell, or a plurality of such cells, with a heat-responsive sensor such as an infrared detector at a rate of scan and scan traverse selected to provide information of thermal abnormalities resulting from the abnormal current density which is caused by incipient short circuits. In a preferred embodiment of the present invention, an infrared scanner is repetitively swept across the cell area undergoing investigation while simultaneously being traversed along a direction transverse to the direction of scan, with the scan and traverse rates being adjusted to provide substantially contiguous scan paths along the surfaces of the cells, with substantially no scan overlap and with substantially no scan "underlap," that is, no unscanned area between two consecutive scans. The scan and traverse rates are established to provide at least a minimum number of scans of a unit area under investigation.

Turning next to the disclosed embodiment of the present invention, FIG. **1** shows in schematic view a portion of an exemplary electrolytic metal refining cell shown generally at **10** and including a tank **11** containing a plurality of interposed cathodes **12** and anodes **13.** Each of the cathodes **12** is connected to a negative electrical bus **14,** while each of the anodes **13** is correspondingly connected to a positive electrical bus **15.** The tank **11** is substantially filled with an appropriate electrolyte **16** which, in the case of a copper refining cell as aforementioned, may appropriately be copper sulphate. Those skilled in the art will realize that the cathode and anode electrodes actually used in an electrolytic copper refining operation have particular shapes and configurations, with such shape configuration details purposely omitted from FIG. **1** for the purpose of clarity in illustrating the present invention. Furthermore, although the disclosed embodiment of the present invention is in the context of a copper refining operation, it will be apparent to those skilled in the art that the present invention can be used in other metal refining operations, as well as in electroplating operations generally, to detect the presence of incipient short-circuit conditions therein. The reference to a cooper refining operation is by way of example only, and is without intent to limit the present invention to use in the context of copper refining.

An infrared scanner **20** is suspended from or otherwise mounted on a carrier **21** mounted for transverse movement along a support member **22** which is, in turn, mounted for selective controlled movement along the path **23** corresponding to the lateral direction of the cell tank **11.** For a typical embodiment of the present invention as installed in a production metal refining facility, the support member **22** may advantageously be provided by a travelling bridge crane which is usually present in such a facility and which travels along rails (not shown in FIG. **2**) suspended above the sides of the bay or other work area in which a plurality of the cells **10** are positioned. Travelling bridge cranes typically have a hoist carrier which is capable of transverse motion in a direction **24** parallel to the support member **22,** and this transverse motion **24** is useful for a purpose described below. It will be understood, of course, that the use of an existing crane to support the infrared scanner **20** is optional, inasmuch as the infrared scanner can alternatively be provided with a separate and independent support apparatus. It will be understood by persons skilled in the art that the lateral directional movement of the infrared scanner relative to the cell tank, in the described embodiment of the invention, is determined by the existing positions of the cells and the bridge crane. The scanner may be moved in any suitable direction which enables the desired surface area of the cells to be scanned, including scanner movement at a right angle to the movement depicted in FIG. **1.**

The infrared scanner **20** used in the disclosed embodiment of the present invention is of the type which repetitively sweeps an instantaneous field of view **25** along a path **28** defined by the predetermined scanning arc **26.** Infrared scanners of this type are known to those skilled in the art, and typically include a rotating mirror which reflects the radiation collected from the field of view **25** through an optical system for focusing onto an infrared detecting element, whereat the instantaneous level of detected infrared energy is converted to an analog electrical signal. Infrared scanning apparatus of this type is available, for example, from the Barnes Engineering Company of Stamford, Conn.

The scanning arc **26** is preferably at least of sufficient magnitude, considered with the elevation **27** of the infrared scanner **20** above the surface of the cell **10** being scanned, which allows the entire length of at least one cell to be scanned. By way of example, a scanning arc **26** of 90° is sufficient to scan a tank **11** having a length of 50 ft., with the scanner **20** positioned at an elevation **27** of 25 ft. above the tank. A typical state-of-the-art infrared scanner **20** thus positioned will produce an instantaneous field of view **25** of approximately 0.25 inch resolution at the tank surface directly below the scanner.

It is necessary to the detection of incipient short-circuit conditions, as encountered in the electrolytic refining of copper, that the present invention has the ability to detect thermal abnormalities on a minimum length of cell metallic member such as an anode, a cathode, or the supports therefor, which minimum length usually has a dimension of at least one inch. An incipient short-circuit is caused by the occurrence of some abnormal condition which causes a localized current density which is somewhat greater than the nominal current density in locations surrounding the thermal abnormality. For example, the electrolytic refining process may cause a nodule of refined copper to commence growing outwardly from a cathode to an adjacent anode. When the nodule initially grows into contact with the anode, the current density at the location of nodule contact is increased and, as the growth of the nodule continues, the abnormally-high current density continues to increase. The aforementioned increased current density at the nodule location, for example, causes a relative temperature increase or hot spot, and detection of this hot spot at the earliest practical time permits prompt corrective measures to be taken to minimize loss of production and wasted electricity.

To achieve the proper detection of a hot spot having the aforementioned dimension of at least one inch as measured in the direction **23** of scanner travel, it has been determined to be necessary to sweep that hot spot with at least two consecutive scans of the scanner field of view **25.** Assuming a nominal field of view **25** of 0.25 inches and a scan repetition rate of 60 scans per second, in the disclosed embodiment, it becomes necessary to provide a scanner travel velocity of 75 feet per minute in the direction **23,** to accomplish scanning of the entire tank surface with side-by-side contiguous scan paths **28,** so that neither any unscanned area nor any scan overlap exists between any two contiguous scan paths **28.** It has been found that satisfactory operation of the present invention is obtained with scan repetition rates in the range of 40–120 scans per second, with the scanner travel velocity correspondingly adjusted to the rate which is required to make each successive scan path **28** contiguous with the immediately preceding scan path.

Considering next FIG. **2,** there is shown a plan view of a typical bay of a tankhouse for the electrolytic refining of a metal such as copper. The bay, shown generally at **33,** contains a number of electrolytic cell sections **42,** with each such tank section containing a plurality of cells **10** which may be substantially similar to the cells **10** of FIG. **1.** The cell sections **42** are arranged in four rows, as shown in FIG. **2.** The support member **22** is the cross beam of a travelling crane mounted for powered movement along the two rails **34** and **35,** and the scanner carrier **21** is mounted for transverse movement along the travelling crane. The signal output from the infrared scanner, along with control signals and operating power required of the scanner, are supplied by a suitable cable arrangement **36** supported in a festoon system or any other arrangement which is appropriate to permitting the necessary travel of the crane. A telemetry or similar system may be used in place of cable arrangement **36.** Positioned at opposite ends of the crane rail **35** is a pair of switches **37** and **38** which are actuated by movement of the crane at the switch positions and which provide signals denoting the beginning and the end of a scanning pass over a particular row of tank sections. A plurality of pulse switches **39***a*–**39***f* are also positioned adjacent the crane rail **35** to be actuated by passage of the crane therealong, with each such pulse switch being positioned in predetermined relation to an end of one of the tank sections. The signals from the two switches **37** and **38** are supplied to a control cable **40,** while the outputs of the pulse switches **39***a*–**39***e* are supplied to a control cable **41**; these two control cables, along with the cable **36** connected to the infrared scanner, are supplied to the display apparatus as shown on FIG. **3.**

Considering next FIG. **3,** it can be seen that the lines **36** and **40** are connected to provide inputs to a facsimile recorder **44** of the type which provides a permanent recording **45** of an input signal. The input signal to the facsimile recorder **44** is the electrical signal provided by the infrared detecting element in the scanner **20,** and this input signal is identified on FIG. **3** as the "video signal" supplied on the cable **36.** The facsimile recorder **44,** as is known to those skilled in the art, includes a mechanical drive mechanism which moves recording paper at a constant predetermined rate past a recording device which traverses the width of the recording paper in synchronism with the repetitive scanning of the field of view **25** provided by the infrared scanner **20.** Since the video signal supplied to the recorder **44** is function of the temperature of each scanned location on the surface of a tank **11,** the resulting recording **45** may be likened to a thermal map of the tank surface.

The video signal and position sync signal may also be supplied along lines **36, 46***a* and **41, 46***b*, respectively, to a cathode ray tube (CRT) display **47,** if desired, which can be operated to provide an instantaneous visual display of the thermal signal provided by each scan path **28** across a cell **10.**

Considering the operation of the embodiment as herein described, it is assumed that the crane **22** and the carrier **21** are initially positioned as shown in FIG. **2.** After the infrared scanner **20** (not shown in FIG. **2**) and the facsimile recorder **44** are turned on, the crane **22** is controlled in the conventional manner to commence movement along the rails **34** and **35** toward the opposite end of the bay **33.** Movement of the crane past the switch **37** supplies a scan start signal along the line **40** which may advantageously be connected to commence paper movement in the facsimile recorder, thus automatically initiating recording of a scan run. Further motion of the crane actuates the first pulse switch **39***a*, positioned in known relation to the first tank section **42** to be traversed by the scanner, and the signal provided by this and the subsequent pulse switches functions as a synchronization signal to insure that the CRT display **47** allows a complete recording sweep of the CRT screen for each section **42** of individual electrolytic cells.

The foregoing scanning operation, identified on FIG. **2** as "scan No. **1**" continues until the crane **22** actuates the switch **38** to signal the end of the first row of cell sections. The paper drive of the facsimile recorder **44** is automatically terminated, and the scanner carrier **21** must next be repositioned along the crane **22** to be in alignment with the second row **48** of cell sections. Once this has been accomplished, crane travel is again initiated and actuation of the switch **38** signals commencement of the next scanning run and the start of the recording paper for the next scanning run, identified on FIG. **2** as "scan No. **2.**" Following the commencement of scan No. **2**, the scanner carrier is again repositioned to scan row **49**, and then to scan row **50**.

FIG. **4** is an actual photograph of a facsimile recording **45** known as a "thermogram" and made of a cell section **42** in an electrolytic copper refining operation, with the cell section having been in operation for a period of 1 hour. This cell section consists of 13 numerically-designated cells, with each cell having 33 numerically-designated cathode positions. In the thermogram of FIG. **4**, the light areas represent the presence of heat relative to the darker (cooler) portions depicted on the thermogram. The thermogram was made with the facsimile recorder **44** adjusted to provide a contrast such that the surface area of the electrolyte in the cells appears white, as exemplified at **55** on FIG. **4**. This preset contrast, made with reference to the known or readily ascertainable temperature of the electrolyte in the cells, provides a convenient reference temperature against which other temperatures on the thermogram may be compared. The horizontal dark lines on the thermogram, such as the line **56**, represent hanger bars which are positioned above the electrolyte to support the cathodic starter sheets. The hanger bars, as represented by the dark line **56**, normally are considerably cooler than the electrolyte in the cells.

The existence of thermal conditions corresponding to incipient short-circuits is illustrated by the following. Considering cells 12 and 13 at positions 19 and 20, respectively, white areas **57** and **58** are present where dark hanger bar lines should normally occur. An inspection of the corresponding cell positions indicated that the starter sheets connected to the hanger bars at the foregoing positions were bent, resulting in abnormal current density conditions which produced the heating of the hanger bars.

Another obvious abnormality can be seen in cells eight and nine at position 22, indicated at **59** on FIG. **4**. Inspection of this location confirmed that the hanger bars of the adjacent cells were in direct contact with each other.

In cells five and six, at position 21, the white areas **60** and **61** indicate hot spots in the hanger bar. Inspection of this location revealed that the hanger bar was contacting a support lug of the cell anode, in each of cells five and six.

In cell four, position six, about one-third of the hanger bar appears in a relatively gray tone as at **62**. Examination of the cell position revealed a starter sheet which apparently had been damaged in initial loading into the cell. Position seven of cell four, as at **63**, is also lighter in gray tones than the normal bar. Again, anode contact with the hanger bar was found to be the cause.

Further in cell number four, at position 24, the faintly visible hanger bar depicted at **64** was caused by a cathode sheet having a bent corner, giving rise to a current density abnormality which produced the detected hot spot.

The foregoing recitation and identification of specific hot spots on FIG. **4**, and the operational cause of each hot spot, is only exemplary of the cell abnormalities which are detectable according to the present invention. Moreover, it can be seen that there are numerous other hot spots depicted on FIG. **4** which, although not specifically discussed herein, are indicative of other cell positions which require personal inspection and corrective action. Scanning an entire bay **33**, consisting of four separate rows of cell sections, takes approximately 16 minutes at 75 feet/minute, plus time to reposition the scanner, according to the disclosed embodiment of the present invention, and the resulting thermograms can be relatively rapidly examined to determine the specific locations of thermal abnormalities indicative of possible incipient short circuits. It will be understood, of course, that short circuit conditions which have developed to a magnitude to be detectable with conventional gauss meter measurement typically cause thermogram hot spots of even greater prominence than the hot spots caused by incipient short-circuit conditions, and so such short circuits are also detectable by the present invention. The inspection personnel, after reviewing the thermograms, can proceed immediately to the suspect cells and electrode positions without wasting valuable time in a routine, manual inspection of each and every cell position as previously done according to prior art techniques.

Use of a thermal detection method and apparatus according to the above-disclosed specific embodiment of the present invention has demonstrated that incipient short-circuit conditions can be detected as much as 24 hours prior to earliest possible detection of such conditions with conventional gauss meter or voltmeter apparatus. Moreover, a complete thermal inspection of all cells can be made one or more times during each work shift, without requiring a substantial expenditure of manual inspection labor and without necessitating hazardous walking on the cells. The thermograms produced according to the present invention provide a permanent record of each cell position at various times during the operating life of the cell, and constitute a source of data against which the work of the inspection crews and the refined copper production of the cells can be evaluated. In the foregoing actual working embodiment, the nominal cell current density of 14 amperes per square foot was approximately one-half of the maximum current density for which the tankhouse was designed, such reduced current density being maintained for experimental purposes, and so it is reasonable to assume that the 24 hour advantage provided by the present method over conventional gauss meter techniques would correspond to a 12 hour advantage when the tankhouse is operated at full current density.

Moreover, it will be understood that the foregoing relates only to a preferred embodiment of the present invention, and that numerous alterations and modifications may be made therein without departing from the spirit and the scope of the present invention as set forth in the following claims.

We claim:

1. Method of detecting the presence of an incipient short-circuit condition of an electrode immersed in electrolytic solution, comprising the step of repetitively scanning the electrode to examine the amount of infrared energy radiating from the electrode, said scanning occurring at a rate of no less than two nonoverlapping scans of at least about 0.25 inch of width per inch of electrode in 1/120 of a second.

2. In an electrolytic refining operation including at least one electrolytic tank containing an electrolyte and having a plurality of spaced apart electrodes disposed in the electrolyte, the method for detecting the location of an incipient short-circuit condition resulting in an abnormal localized current flow and manifested by an abnormal output of infrared radiation from such location, comprising the steps of:

repetitively scanning a surface of the electrolytic tank along a path of certain width to measure the amount of infrared radiation emanating therefrom, the width of said scanning path being only a fractional portion of a dimension of said electrolytic tank;

traversing said scan path in a direction at a substantial angle to said scan path so that each successive repetitive scan passes along a previously unscanned portion of the surface of said electrolytic tank; and

selecting the width of said scan path relative to a desired minimum width of detectable incipient short-circuit location so that a said location is scanned by at least two successive repetitive scan paths.

3. The method as in claim **2**, wherein substantially no overlap of said two successive scans occurs.

4. The method of claim **2**, wherein there is substantially no unscanned area between said two successive scans.

5. The method as in claim **2** wherein a detectable said location of an incipient short-circuit condition has a dimension of at least about 1 inch in extent, and the width of each said scan path is at least about 0.25 inch.

6. The method as in claim **5**, wherein said scan path is traversed in a direction substantially perpendicular to said scan path.

7. The method as in claim **5**, wherein said repetitive scan occurs at a rate in the range of about 40–120 scans per second inclusive, and said predetermined rate of traverse is the rate at which each consecutive scan is contiguous with immediately preceding scan at the particular rate of repetitive scan.

8. The method of claim **5**, wherein said two consecutive scans are substantially contiguous with each other.

9. Apparatus for detecting the existence of an incipient short-circuit condition in an electrolytic tank containing a plurality of spaced apart electrodes disposed in an electrolyte within the tank, with an incipient short-circuit condition being manifested by an abnormal output of infrared radiation from a location on the electrolytic tank, comprising the combination of:

infrared responsive means supported in elevated spaced apart relation above the electrolytic tank and operative to repetitively sweep a portion of the open electrolytic tank with a scan path having a certain width;

traversing means mounted above the electrolytic tank and supporting said infrared responsive means, said traversing means being operative to move said infrared responsive means over the electrolytic tank at a substantial angle to said scan path and at a predetermined rate of speed which causes a said location of previously determined minimum detectable size to be scanned by at least two successive scan paths.

10. Apparatus as in claim **9**, in which such electrolytic tank is one of plural such tanks arranged in a row in a tankhouse, and said traversing means is mounted in spaced relation above said row and is operative to traverse said scan path across the surfaces of each of said plural electrolytic tanks in predetermined sequence.

11. Apparatus as in claim **9**, wherein said infrared responsive means scans a path having a width of at least about 0.25 inch on the electrolytic tank.

12. Apparatus as in claim **11**, wherein said traversing means is operative to traverse said scanning path at a rate which results in substantially no overlap of said two consecutive scan paths.

13. Apparatus as in claim **11**, wherein said traversing means is operative to traverse said scanning path at a rate which leaves substantially no unscanned area between said two consecutive scan paths.

14. Apparatus as in claim **11**, wherein said traversing means is operative to traverse said scanning path at a rate whereat said two consecutive scan paths are substantially contiguous.

15. Apparatus as in claim **11**, wherein said traversing means is operative to traverse said sensor means at a predetermined rate of speed which causes said at least two consecutive scan paths to occur over a distance of no more than 1 inch as measured in the direction of traverse.

16. Apparatus for detecting the presence of an incipient short-circuit condition in a section of electrolytic cells each of which cells contain plural electrode elements, comprising:

traversing means mounted in elevated relation to the section of electrolytic cells and selectively operative to traverse a certain predetermined path relative to such cells;

switch means positioned to provide a control signal condition in response to the presence of said traversing means at a certain location corresponding to the beginning of said traverse path over a section of cells;

sensor means carried by said traversing means and operative to provide an output signal responsive to the amount of thermal energy which strikes a predetermined sensing area of said sensor means;

scanning means operatively associated with said sensor means to repetitively sweep said sensing area at a predetermined rate along a predetermined scanning path in angular relation to said path of traverse;

readout means connected to receive said output signal and selectively operative to provide an output display which is a function of time and of said output signal;

circuit means connecting said switch means to said readout means; and

said readout means being operative to commence providing said output display in response to said control signal condition.

17. Apparatus as in claim **16**, for use with a number of sections of electrolytic cells, wherein:

said traversing means is mounted to traverse each section of cells in said elevated relation and along said certain predetermined path;

said switch means is positioned to provide said control signal condition in response to said traverse means being at a certain location relative to the beginning of a first section of cells to be traversed.

18. Apparatus as in claim **16**, for use with a number of sections of electrolytic cells, comprising:

said traversing means is mounted to traverse each section of cells in said elevated relation and along said certain predetermined path;

additional control switch means positioned to provide additional control signal conditions in response to said traverse means being at a certain location relative to each of the sections of cells; and said readout means operative to provide a cell section display condition in response to each of said additional control signal condition.

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